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Gleaning the Gleam: A Deep-Sea Webcam Sheds Light on Bioluminescent Ocean Life

With help from a special Webcam, a marine biologist exposes undersea bioluminescence and helps illuminate the shady world of deep-sea life

By Ferris Jabr

If you trawl a net through the ocean's depths, chances are just about every living thing you haul to the surface will be able to glow. Marine biologists estimate that between 80 and 90 percent of deep-sea creatures are bioluminescent—they produce light through chemical processes.

Like the deep sea itself, the reasons why many of these organisms flash, twinkle and gleam remain mysterious to science. But in the past decade marine biologist Edith "Edie" Widder has tackled more puzzles about undersea bioluminescence than any other researcher. Widder has pioneered new technologies designed specifically to study bioluminescence and, in the process, discovered new species and recorded footage of never-before observed animal behavior. Now, as president and senior scientist of the Ocean Research and Conservation Association (ORCA), Widder is currently preparing to launch a new, cheaper and more portable version of her unique deep-sea camera, which she uses to observe rarely glimpsed ocean life completely undisturbed. She has plans to create a high-resolution color camera as well.

Seeing the light

In the 1980s, while completing her PhD in neurobiology at the University of California, Santa Barbara, Widder spent a lot of time studying the cellular activity of bioluminescent dinoflagellates, a variety of marine plankton. Inside certain cells of bioluminescent organisms an enzyme called luciferase catalyzes a light-producing reaction between a pigment called luciferin and oxygen. Different species have different variants of the enzyme and pigment, but oxygen is the essential ingredient that unites them all. Once Widder became an expert on both the biology of bioluminescence and the sophisticated equipment used to measure it, she began joining trawling expeditions that dragged nets to collect glowing ocean creatures and analyzed the light they emitted. On one of the research expeditions, Widder had the chance to test an atmospheric deep-sea diving suit called WASP, which resembles a submersible suit of armor. It was her first dive, but it would not be her last.

WASP allowed Widder to immerse herself in the ocean's bioluminescence—to really see the ubiquity of undersea illumination firsthand. One dive was particularly memorable. "I was trying to take some readings with a meter," Widder says, "when suddenly the whole inside of the suit lit up blue." Widder had brushed up against a chain of siphonophores—a colony of jellyfish relatives—sparking their light show. "It was breathtaking, absolutely breathtaking," Widder says. "Especially if you know how much energy is involved in that kind of photon production—it's so energetically costly for the siphonophores."

That experience helped Widder decide what to do with her PhD: make marine bioluminescence the center of her life's work, no matter what it took. She couldn't understand why more scientists were not investigating how and why ocean organisms produce light. And she wanted to answer all her own questions. But first, she needed to design instruments with which she could study bioluminescence—instruments that did not yet exist.

Glimmering gadgets

Although submarines and submersibles like WASP taught Widder a lot about bioluminescence and marine life in general, she wanted to observe but not disturb: no bulky vehicles, no lights, no humans in waterproof suits of armor—just the fish and an invisible observer. So she designed a camera called Eye-in-the-Sea. Widder first tried to secure funding for the project in 1994, but could not convince any single agency of the project's potential. Instead, she pieced together the camera bit by bit over many years with a series of collaborators. The instrument began as a student project for the Harvey Mudd College Engineering Clinic in the fall of 2000. Later, funding from the National Oceanic and Atmospheric Administration (NOAA) and the Monterey Bay Aquarium Research Institute (MBARI) enabled Widder to build the camera's frame and purchase an underwater battery. In 2002 Widder conducted preliminary tests in the Monterey Submarine Canyon off the California coast.

The Eye-in-the-Sea relies solely on an external source of far-red light to illuminate its surroundings. Most deep-sea creatures cannot see red light, because their eyes evolved to focus on the shorter blue and green wavelengths that travel furthest through water. Thanks to this fact, red light allows the camera to observe deep-sea organisms without disturbing them. Because red light is readily absorbed by seawater, the Eye uses an ultrasensitive black-and-white camera that amplifies the dim far-red-light illumination and is also sensitive enough to record any bioluminescent creatures swimming within range.

But Widder didn't leave the camera alone and hope glimmering creatures would swim by. Instead, she used her knowledge about bioluminescence to design a unique lure. Widder created an electronic jellyfish that mimics the light shows of living bioluminescent jellyfish using a circle of 16 blue LEDs that flash in patterns. Specifically, the robot jellyfish mimics the atolla jellyfish (*Atolla wyvillei*), which employs light displays as a distress call when confronted by predators, signaling for even bigger predators to interfere and possibly rescue them. Her idea is that the robo-jelly would attract these same big marine predators to the camera.

Fishy footage

In 2004 Widder deployed the camera in the Gulf of Mexico. What she discovered there proved beyond a doubt how effective the Eye-in-the-Sea could be when paired with its electric jelly companion.

Fish swam up to and all around the underwater camera completely undisturbed. After four hours of collecting footage, Widder switched on the electronic jellyfish, which began its pinwheel light show. A mere 86 seconds after it started glowing the robot attracted a squid around two meters long—a species that no scientist had ever documented before. Widder thinks this is exactly the kind of big marine predator a living bioluminescent jellyfish might attract when under attack by smaller predators, in the hopes of saving itself.

In fact, communication is one of the main functions of underwater bioluminescence, Widder explains, enabling marine creatures to locate prey, attract mates and avoid predators. "What you [have] got to realize is that the open ocean environment is the largest habitat on the planet and the animals out there have to play all the same games that animals play on land," Widder says. "They need places to hide, too, and ways to communicate and see each other—whether they are looking for food or sex. But they spend most of their life in this twilight realm. So they evolved lights."

Over the years, Widder's curiosity has helped science better understand how many of the strangest bioluminescent ocean creatures communicate and interact with one another. Consider the cookie-cutter shark: sure, it sounds adorable, but this shark is a devious hunter—and Widder suspects bioluminescence is a key part of its arsenal. The shark's bioluminescent stomach acts as an invisibility cloak that conceals its own shadow by matching the intensity of light shining from above—a trick called counterillumination. But a dark collar on its throat mimics the silhouette of a fish, luring bigger fish. When one of those hungry predators gets close enough to what it thinks is its next meal, it winds up as a meal itself. The shark takes a vicious chomp out of its deceived prey, leaving a cookie cutter–shaped wound.

If that is not strange enough, there's also the scaleless dragonfish (*Pachystomias microdon*), which can emit and perceive red light. Because most deep-sea creatures cannot see in this color, the dragonfish uses its bioluminescent organs like an infrared sniper scope to hunt, illuminating its surroundings without its prey noticing anything unusual.

Widder recently discovered that an octopus she calls the red balloon octopus (*Stauroteuthis syrtensis*) has bioluminescent suckers that are morphing into genuine light organs. "It corroborates the view of how bioluminescence evolves," Widder says. "It's an open-ocean octopus, so it doesn't really need suckers anymore to cling onto things on the bottom. But in the dark depth of [the] ocean, it needs light." Widder thinks the octopus uses its shimmering suckers to attract prey, like small crustaceans called copepods.

One tiny critter still baffles Widder: the shining tubeshoulder fish (*Sagamichthys abei)*, which squirts not just chemical light—but entire cells—from its shoulder when stimulated. "Why that one fish would eject whole cells seems incredibly costly and odd," Widder says. "It may have evolved from some other mechanism we don't know anything about. I'm still mystified by that one."

Always on the glow

Soon, Widder plans to launch an updated version of the deep-sea Webcam, which is cheaper, lighter and more portable. "We're just completing a new version of the Eye-in-the-Sea camera system, which has been a collaboration between myself and Justin Marshall [of the University of Queensland in Australia]," Widder says. "We brainstormed about how to make the lowest cost version of the camera as possible, so we could have a lot of them. My version of it is about to come out of the shop in a matter of weeks. The original version is kind of cumbersome, whereas the new version is what we call a lander system: You throw it off the back of a boat, it floats down to the bottom, lands on the bottom, and keeps running the whole time. This new version will be used in a number of different scenarios, like looking at goliath grouper spawning behavior."

Widder also has plans to create a high-resolution version of the Webcam that can record in color, which would better help her distinguish between different kinds of bioluminescence. Although most deep-sea creatures emit light in the blue or green wavelengths, underwater bioluminescence comes in many more colors. "Blue is what travels farthest through seawater, but there are lots of different colors I am curious about: red, orange, yellow, violet and even extending into the ultraviolet," Widder says.

The applications of research on bioluminescence also excite Widder's curiosity. "We are using bioluminescence in a number of different ways to protect the ocean," she says. "We are using bioluminescent bacteria to detect toxins in ocean sediments, develop pollution gradient maps and perform water quality monitoring. Since bioluminescence in bacteria is directly linked to the respiratory chain, anything that depresses respiration—like toxins—depresses illumination. That way, we can tell you exactly how unhealthy a sediment is."

Name/Period/Date

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1. What percent of deep-sea creatures are estimated to be bioluminescent?
2. How does bioluminescence work?
3. Who are NOAA and MBARI?
4. Why does the Eye-in-the-Sea use red light to illuminate the deep?
5. How does the cookie cutter shark use bioluminescence?
6. What are some benefits of the newer Eye-in-the-Sea webcam?
7. How is bioluminescence being used to protect the ocean?